Boeing Phantom Works
Lean and Efficient Processes and Tools

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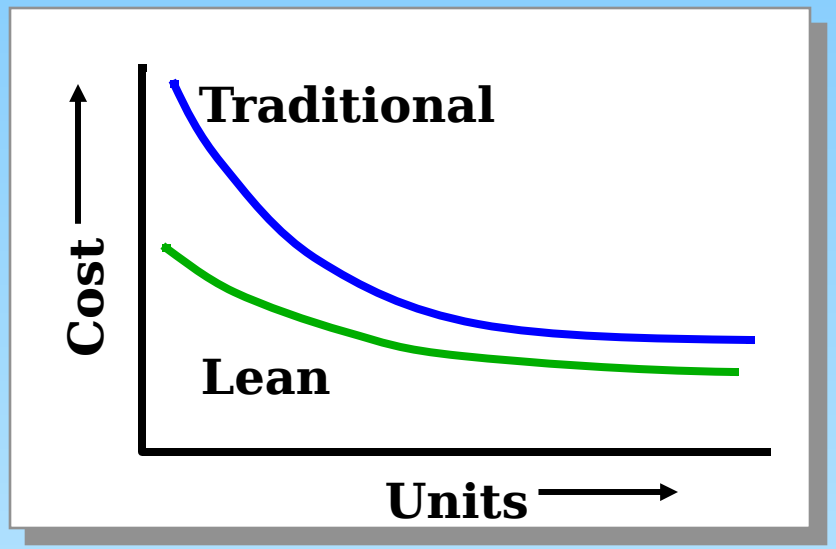
Boeing-Lean Engineering Public Release Control No. 00-0

Lean Enterprise Thrusts

Lean Engineering

- Parametric 3D Solids
- Dimensional Management
- Virtual Manufacturing
- Model Based Definition (Int/Ext)
- Single Source of Product Data
- Virtual Collaboration



Lean Manufacturing

- Throughput Studies
- Variability Reduction/SPC
- HPWOs
- AIWs
- Advanced Technology Assembly
- Operator Verification

Lean Supplier Management

- Supplier Base Reduction
- Certified Suppliers
- Suppliers as Partners
- Electronic Commerce/CITIS
- IPT Participation

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Goals and Metrics Based on 2nd Generation Experience

Boeing Improvement Goals

	Reduce Cost	Reduce Cycle Time	Improve Quality
Non-Recurring Development	50%	50%	90% ①
First Unit Fab & Assy (T1)	66%	50%	90% ②
Recurring (Production)	50%	50%	90% ②
Support (O&S)	50%	-	-

① Based on Changes After Initial Release (REV's, EO's, DCN's, etc)
② Based on Quality Tags per 1000 Std Hours

Explicit Recognition that 80% of Product Cost is Locked-in by Product Definition

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Virtual Manufacturing Reduces Rework and Improves Learning

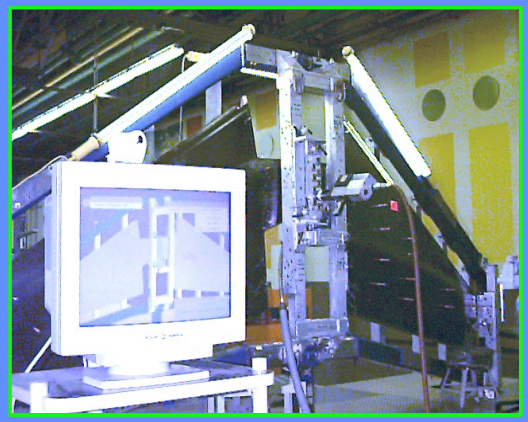
Development in the Virtual Factory

Affordable, Low Risk Deployment in the Real Factory

Assembly/Tooling Validation
- **Tooling Interference Checks**
- **Part to Part Interference Checks**
- **Optimized Sequence Flow**
- **Incorporates TUI's**

Traditional

T_1



Savings

T'_2

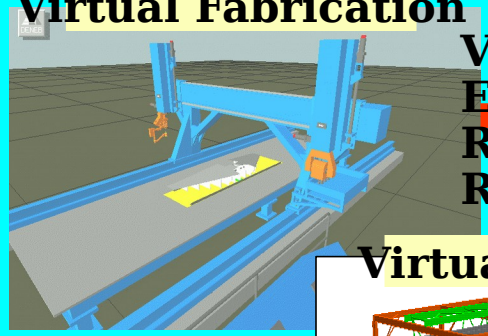
Savings in Rework and Product Definition Changes

Mfg. Cost

Production Units

Virtual Manufacturing Tools Support Lean Manufacturing

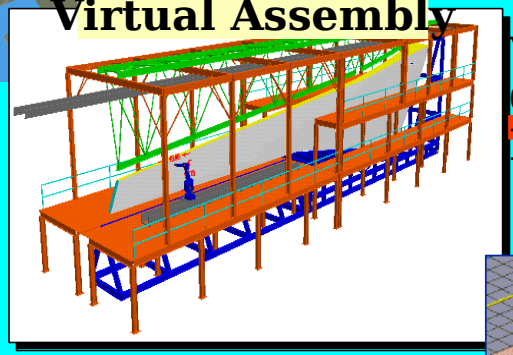
Virtual Fabrication



Validation of NC Programs
Elimination of Machine Collisions
Reduction of PTO's
Reduced/Eliminated Rework

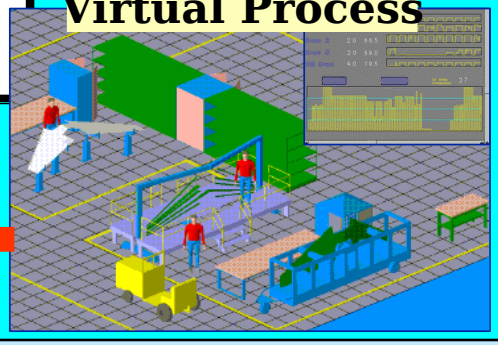
Virtual Factory

Virtual Assembly



Validation of Assembly Process
Optimized Assembly Sequences
Product Improvement Changes
w/o Line Disruption

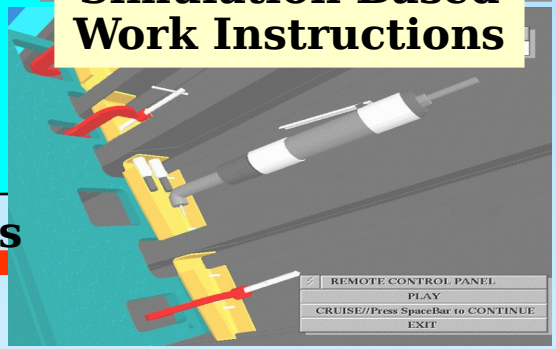
Virtual Process



Increased Factory Throughput
Improved Asset Utilization

Production Factory

Simulation Based Work Instructions



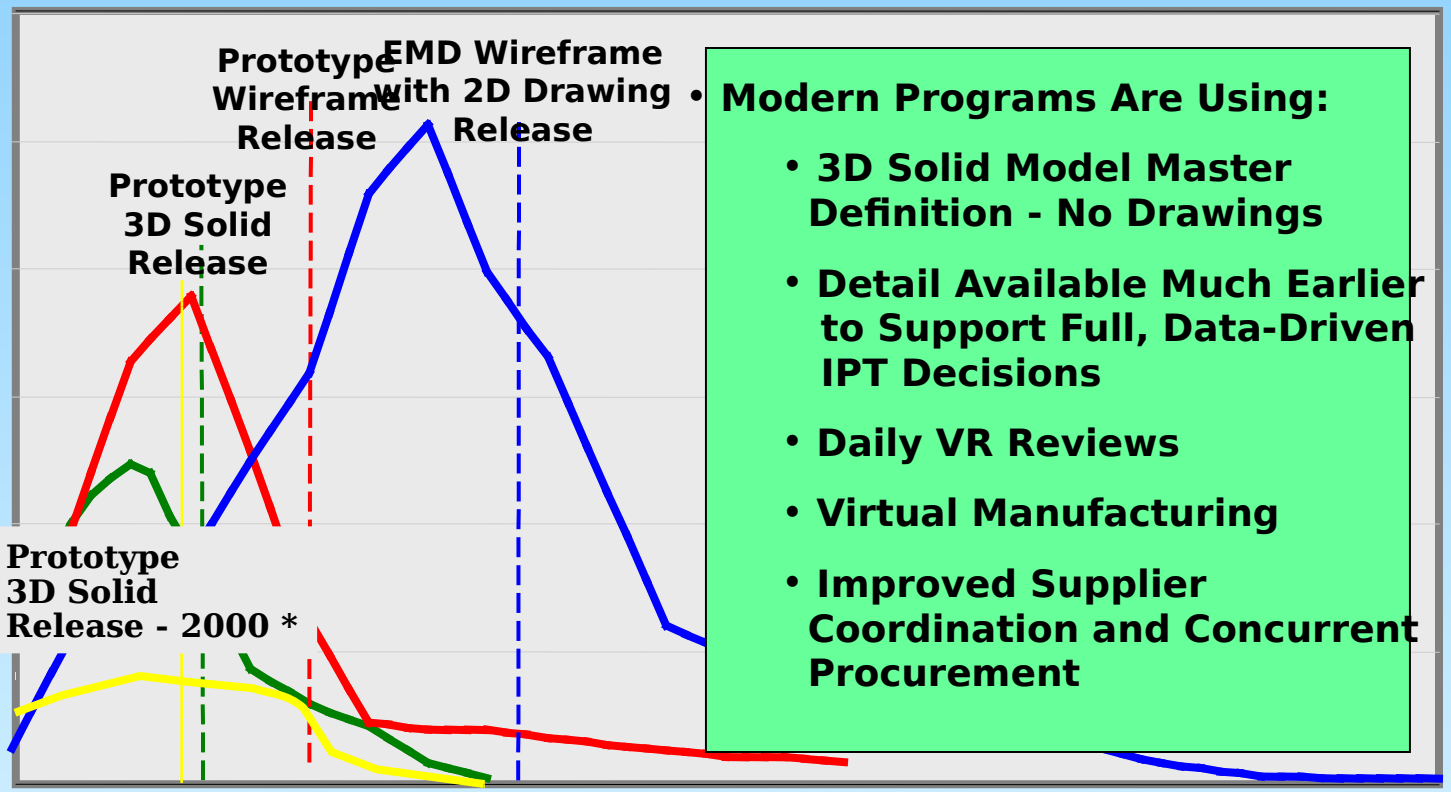
Enhanced Work Instructions
Workforce Flexibility
Lower Assembly Hours

Virtual Manufacturing Validates the Product Definition, Optimizes the Manufacturing Plan and Costs, and Simplifies Worker Training and Work Instruction Quality

Supportability Tools Significantly Reduce Operations and Support Costs

Lean Engineering Product Definition Process Significantly Reduce NonRecurring Cost and Cycle Time

Forward Fuselage Development
Total IPT Labor


Prototype Wireframe Release
EMD Wireframe with 2D Drawing Release
Prototype 3D Solid Release
Prototype 3D Solid Release - 2000 *
Staffing Level
Months from End of Conceptual Design Phase
• Modern Programs Are Using:
• 3D Solid Model Master Definition - No Drawings
• Detail Available Much Earlier to Support Full, Data-Driven IPT Decisions
• Daily VR Reviews
• Virtual Manufacturing
• Improved Supplier Coordination and Concurrent Procurement

ates results from vehicle of approximate size and work content of forward fuselage

Summary

- **Significant Progress Made in Reducing Design Cycle Time and Personnel**
- **Early Redesign Efforts Demonstrated Manufacturing Benefits**
- **Simulation-Based Work Instructions Emerged as an Enabler for Improving Realization Factor**
- **Tools Have Been Developed That Facilitate Meaningful Up-Front Supportability**
- **Prototype Forebody Demonstrated the Full Potential of Lean Engineering Tools**
- **Simulation Has the Potential to Significantly Reduce**

odeling & Simulation Applications Have Result in a Paradigm Shift in Product Development